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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

AN INVESTIGATION OF THE FREE-SPINNING AND RECOVERY CHARACTERISTICS OF A 1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE WITH ALTERNATE NOSE CONFIGURATIONS WITH AND WITHOUT WING FUEL TANKS

TED NO. NACA AD 395

By James S. Bowman, Jr.

Langley Aeronautical Laboratory
Langley Field, Va.

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AN INVESTIGATION OF THE FREE-SPINNING AND RECOVERY CHARACTERISTICS OF A 1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE WITH ALTERNATE NOSE CONFIGURATIONS WITH AND WITHOUT WING FUEL TANKS

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SUMMARY

A supplementary investigation has been conducted in the Langley 20-foot free-spinning tunnel on a 1/24-scale model of the Grumman F11F-1 airplane to determine the spin and recovery characteristics with alternate nose configurations, the production version and the elongated APS-67 version, with and without empty and full wing tanks.

When spins were obtained with either alternate nose configuration, they were oscillatory and recovery characteristics were considered unsatisfactory on the basis of the fact that very slow recoveries were indicated to be possible. The simultaneous extension of canards near the nose of the model with rudder reversal was effective in rapidly terminating the spin. The addition of empty wing tanks had little effect on the developed spin and recovery characteristics. The model did not spin erect with full wing tanks.

For optimum recovery from inverted spins, the rudder should be reversed to 22° against the spin and simultaneously the flaperons should be moved with the developed spin; the stick should be held at or moved to full forward longitudinally.

The minimum size parachute required to insure satisfactory recoveries in an emergency was found to be 12 feet in diameter (laid out flat) with a drag coefficient of 0.64 (based on the laid-out-flat diameter) and a towline length of 32 [redacted]

INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, a supplementary investigation has been conducted in the Langley 20-foot free-spinning tunnel on a 1/24-scale model of the Grumman F11F-1 airplane.

Previous results obtained on tests conducted on a model with an original nose configuration are presented in references 1 and 2. This report presents the results of tests with two longer nose configurations on the model which are referred to as the production nose and the elongated APS-67 nose. The production nose (full scale) is 17.75 inches longer and the elongated APS-67 nose (full scale) is 51.5 inches longer than the original nose. (See fig. 1.) All F11F-1 airplanes manufactured after the 44th airplane will have the elongated nose. The original and production nose configuration airplanes will, therefore, be limited in number.

Erect and inverted spin tests were conducted on the production nose configuration for a center of gravity of 20.6 and 25 percent $\bar{c}$ with and without wing tanks and on the elongated APS-67 nose configuration only for the rearward center-of-gravity position of 25 percent $\bar{c}$ with and without wing tanks. Tests were also conducted to determine the minimum size of a parachute required to insure satisfactory recovery in an emergency. Alternate recovery aids were tested by using canards near the nose and differentially deflected flaps. Tests were also conducted to determine the effects of the refueling probe extended and a dorsal fin. Some of the tests conducted on the model were made both with and without the angular momentum of the jet engine simulated.

SYMBOLS

b wing span, ft

S wing area, sq ft

$\bar{c}$ mean aerodynamic chord, ft

$x/\bar{c}$ ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord

$z/\bar{c}$ ratio of distance between center of gravity and fuselage reference line to mean aerodynamic chord (positive when center of gravity is below line)

m mass of airplane, slugs

I_X, I_Y, I_Z moments of inertia about X, Y, and Z body axes, respectively, slug-ft^2

$\frac{I_X - I_Y}{mb^2}$ inertia yawing-moment parameter

$\frac{I_Y - I_Z}{mb^2}$ inertia rolling-moment parameter

$\frac{I_Z - I_X}{mb^2}$ inertia pitching-moment parameter

ρ air density, slug/cu ft

μ relative density of airplane, $\frac{m}{\rho Sb}$

α angle between fuselage reference line and vertical (approximately equal to absolute value of angle of attack at plane of symmetry), deg

ϕ angle between span axis and horizontal, deg

V full-scale true rate of descent, ft/sec

Ω full-scale angular velocity about spin axis, rps

APPARATUS, METHODS, AND PRECISION

A 1/24-scale model of the Grumman F11F-1 airplane was constructed by the Langley Aeronautical Laboratory for the current tests. A three-view drawing of the model (fig. 1) shows the original nose configuration and the two longer nose configurations as tested in this investigation. The model as tested had an all-movable horizontal tail.

The present investigation simulated only stick laterally neutral conditions for erect spins inasmuch as reference 1 indicated no effect of the flaperons, which provide lateral control for this design.

A photograph showing the model equipped with tanks is shown in figure 2. The model shown has the production nose. The dimensional characteristics of the airplane are presented in table I.

The model was ballasted to obtain dynamic similarity to the airplane at an altitude of 25,000 feet (ρ = 0.001065 slug/cu ft). The mass characteristics and inertia parameters for loadings possible on the airplane and for loadings tested on the model are indicated in table II.

The spin tests simulated both engine-off and engine-on conditions. The angular momentum of the rotating parts of the full-scale Curtiss Wright J-65 jet engine was simulated by rotating a flywheel with a small direct-current motor powered by small silver-cell batteries. The flywheel was located in the model so that the axis of the angular momentum was parallel to the longitudinal axis of the airplane.

The model testing technique is the same as that presented in references 1 and 2. The parachute tests on the model were made with stable flat-type parachutes. The point of attachment of the towline was located at the lower rearward part of the fuselage.

The maximum control deflections (measured perpendicular to the hinge lines) used on the model during tests were:

Rudder:	
Flaps up, deg	5 right, 5 left
Flaps down, deg	22 right, 22 left
Horizontal tail:	
Leading edge down, deg	18
Leading edge up, deg	5
Flaperons, deg	55 up, 0 down

Results determined in free-spinning-tunnel tests are believed to be true values given by models within the following limits:

α, deg	± 1
ϕ, deg	± 1
V, percent	± 5
Ω, percent	± 2
Turns for recovery obtained from motion-picture records	$\pm\frac{1}{4}$
Turns for recovery obtained visually	$\pm\frac{1}{2}$

The preceding limits may be exceeded for certain spins in which it is difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin.

The accuracy of measuring the weight and mass distribution of models is believed to be within the following limits:

Weight, percent	±1
Center-of-gravity location, percent $\bar{c}$	±1
Moments of inertia, percent	±5

The controls are set with an accuracy of $\pm 1^{\circ}$.

Because it is impracticable to ballast models exactly and because of inadvertent damage to models during tests, the measured weight and mass distribution of the F11F-1 model varied from the true scaled-down values within the following limits:

Weight, percent	0 to 1 high
Center-of-gravity location, percent $\bar{c}$	0.7 forward to 0.8 rearward
Angular momentum, percent	12 high to 12 low

Moments of inertia:

I_X, percent	0 to 6 high
I_Y, percent	1 high to 3 high
I_Z, percent	1 high to 3 high

RESULTS AND DISCUSSION

The results of the model tests are presented in charts 1 to 4, table III, and in figure 4. The model tests are presented in terms of full-scale values for the airplane at an altitude of 25,000 feet.

Test results obtained for forward and rearward center-of-gravity positions (20.6 and 25 percent $\bar{c}$, respectively) indicated similar spinning characteristics, except that the duration of the spin was longer and the spin was more easily obtained for the rearward center-of-gravity position than for the forward center-of-gravity position. All results are arbitrarily presented for the rearward center-of-gravity position with the elongated APS-67 nose configuration and for the combat gross weight loading. All spins were similar to the right and left and are arbitrarily presented in terms of left spins.

Erect Spins

The erect-spin test results are presented in charts 1 to 3. The model sometimes spun and sometimes oscillated out of the spin even without control movement for most all control settings, both with and without engine rotation simulated. It is therefore felt that the spin and recovery characteristics of the model with either alternate nose were generally similar to those obtained for the original nose configuration of references 1 and 2.

A factor which is important in analyzing spin-tunnel-model test results is the tunnel testing technique. As pointed out in reference 3, the models are launched into the spin tunnel in a flat attitude with rotation. The corresponding airplane, however, enters a spin from a low angle of attack (such as a 1 g stall). It is thus possible that the airplane may experience greater difficulty getting into a spin than did the model.

Model test results indicate that a very oscillatory spin is possible on the airplane with no wing tanks or with empty tanks (charts 1 to 3) and that, when obtained, it may not be possible to always terminate the motion by full rudder reversal. Extension of canards near the nose of the model simultaneous with rudder reversal was effective in rapidly terminating the spinning motion. The location and size of the canards used in this investigation were the same as those used in references 1 and 2. (See fig. 3.) Model test results (not presented in chart form) indicate that spins could not be obtained on the model with full wing tanks.

Inverted Spins

The order used for presenting the data for inverted spins shows controls crossed for the established spin (left rudder pedal forward and stick to pilot's right for a spin to pilot's left) at the right of the chart and stick back at the bottom. When controls are crossed in the established spin, the ailerons oppose the rolling motion. The angle of wing tilt ϕ in the chart is given as up or down relative to the ground.

Similar to the test results of reference 1, it was indicated that, from any inverted spins obtained on the airplane with no wing tanks, satisfactory recoveries should be obtainable by reversing the rudder to full against the spin ($\pm 5^{\circ}$ rudder travel). When empty tanks were simulated, recoveries were still satisfactory. Test results for inverted spins with no tanks and empty tanks are not presented in charts. When full tanks were simulated, recoveries were unsatisfactory ($\pm 5^{\circ}$ rudder travel). Test results indicated that slow recoveries might sometimes be obtained even with ±22° rudder movement when full tanks were installed (chart 4). As previously indicated, ±22° is the maximum rudder deflection for an alternate condition on the airplane. Rapid recoveries were obtained by rudder movement to 22° against the spin when the flaperons were with the spin prior to the recovery attempt, and it thus appears that it would be desirable to move the flaperons to with the spin in conjunction with rudder reversal for optimum recovery when full tanks are installed. In order not to confuse the pilot, it is recommended that the optimum technique be utilized for recovery from all inverted spins, namely, move the rudder to full (22°) against the spin direction (rudder full right for yawing to pilot's left), simultaneously move the flaperons to with the developed spin (stick full right for yawing to the pilot's left), and hold or move the stick to full forward longitudinally. Upon recovery, which should be evidenced by a steep nose-down attitude, the pilot should neutralize all controls to avoid entering or remaining in a steep rolling motion indicated in chart 4 to be possible.

Parachute Tests

Results of tests conducted to determine the minimum size parachute required to insure satisfactory recoveries in an emergency are presented in table III.

Erect and inverted tests were conducted on the model for both nose configurations with and without wing tanks. The results indicated that a 12-foot-diameter (laid-out-flat) parachute with a drag coefficient of 0.64 (based on the laid-out-flat diameter) and a towline length of 32 feet is required to insure satisfactory recoveries for all configurations and loadings. This parachute size is slightly larger (about 1 foot) than the parachute determined for the original nose configuration in reference 1. This increase may be due to the greater weight simulated for this investigation than for that of reference 1. If a parachute with a different drag coefficient is used, a corresponding adjustment will be required in the parachute size.

Additional Tests

Additional tests were conducted on the F11F-1 model to determine the effects on the spin and recovery characteristics of deflecting wing trailing-edge landing flaps as a recovery device, of simulating the refueling probe, and of installing a ventral fin.

Landing flaps.- Test results indicate (fig. 4) that the deflection of both flaps full down with simultaneous rudder reversal to against the spin would be of no assistance for recovery and that sometimes the rate of rotation of the model increased after flap deflection and thus made recovery even more difficult. The deflection of only the outboard flap full down (right flap in a left spin) in conjunction with rudder reversal led to satisfactory recoveries when the spin rotational rate was below 0.23 revolution per second (full scale). It was indicated, however, that, as the spin rotation rate increased above 0.23 revolution per second, some bad recoveries were also obtained by use of this technique. The rotational rates were varied arbitrarily on the model from 0.21 to 0.31 revolution per second (full scale) by using strakes on the nose. The test results on figure 4 thus indicate that differential deflection of flaps may not always be effective enough to give satisfactory recoveries if the spin rotation of the airplane is above 0.23 revolution per second (full scale).

Refueling probe and ventral fin.- Test results (not presented in chart form) indicate that the refueling probe and ventral fin had no effect on the spin and recovery characteristics. The refueling probe and ventral fin are shown in figures 5 and 6, respectively.

SUMMARY OF RESULTS

Based on results of spin tests of a 1/24-scale model of the Grumman F11F-1 airplane with alternate nose configurations with and without wing tanks, the following conclusions regarding the developed spin and recovery characteristics of the Grumman F11F-1 airplane at an altitude of 25,000 feet are made:

1. The alternate nose configuration and empty tank installation will have little effect. The airplane should not spin however with full wing tanks.

2. When a developed spin is obtained, full rudder reversal will not always insure satisfactory recovery.

3. Full rudder reversal accompanied by extension of properly placed nose canards will lead to satisfactory recovery characteristics.

4. Recoveries from inverted spins obtained with no tanks or empty tanks added to the wings will be satisfactory by full rudder reversal, but, when full tanks are added to the wings, recoveries will be unsatisfactory with $\pm 5^{\circ}$ rudder travel. For optimum recovery from inverted spins, the rudder should be moved to 22° against the spin direction (rudder full right for yawing to pilot's left) and simultaneously the flaperons should be moved to with the spin (stick full right for yawing

to the pilot's left); the stick should be held or moved to full forward longitudinally. All controls should be neutralized upon recovery.

5. The minimum size parachute required to insure satisfactory recoveries in an emergency is 12-feet diameter (laid out flat) with a drag coefficient of 0.64 (based on the laid-out-flat diameter) and a towline length of 32 feet.

6. Deflection of both wing trailing-edge landing flaps down in conjunction with rudder reversal will be of no assistance for spin recovery.

7. The deflection of only the outboard flap (right flap in a left spin) in conjunction with rudder reversal will be very effective in producing satisfactory recoveries provided the spin rotational rate is below 0.23 revolution per second. For rotational rates of 0.23 revolution per second or higher, deflection of the outboard flap will not always insure satisfactory recoveries.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 5, 1958.

REFERENCES

1. Bowman, James S., Jr.: Interim Report on Free-Spinning Characteristics of a 1/24-Scale Model of the Grumman F11F-1 Airplane - TED No. NACA AD 395. NACA RM SL55G20, Bur. Aero., 1955.

2. Bowman, James S., Jr.: Concluding Report on Free-Spinning and Recovery Characteristics of a 1/24-Scale Model of the Grumman F11F-1 Airplane - TED No. NACA AD 395. NACA RM SL56H02, Bur. Aero., 1956.

3. Neihouse, Anshal I., Klinar, Walter J., and Scher, Stanley H.: Status of Spin Research for Recent Airplane Designs. NACA RM L57F12, 1957.

TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE GRUMMAN F11F-1 AIRPLANE

CORRESPONDING TO THE 1/24-SCALE MODEL INVESTIGATED

Overall length:	
Original nose configuration, ft	42.83
Production nose configuration, ft	44.31
APS-67 nose configuration, ft	47.12
Wing:	
Overall span, ft	31.63
Folded span, ft	27.33
Area (exclusive of leading-edge extension), sq ft	250
Mean aerodynamic chord, in.	98.38
Location of leading edge of $\bar{c}$ with respect to fuselage station 0, in.	248.08
Airfoil section:	
Root	NACA 65A006 (modified)
Tip	NACA 65A004 (modified)
Sweepback at 0.25-chord line, deg	35
Incidence, deg	0
Dihedral, deg	-2.5
Aspect ratio	4.0
Taper ratio	0.50
Flaperons:	
Area, sq ft	21.3
Span (perpendicular to fuselage center line), percent b/2	61.7
Trailing edge, percent wing chord	84
Hinge, percent wing chord	70
Trimmers:	
Area, sq ft	2.1
Location (from plane of symmetry), in.	
Root	163
Tip	Wing tip
Hinge line, from fuselage station 0, in.	375.41
Travel:	
Up, deg	5
Down, deg	5
Leading-edge slats:	
Location (from plane of symmetry), in.	
Inboard	75
Outboard	Wing tip
Chord, percent wing chord:	
Root	10
Tip	10
Travel:	
Down, deg	20
Flaps:	
Type	Slotted
Span total, ft	19.83
Leading edge, percent wing chord	80
Trailing edge, percent wing chord	100
Hinge line, percent wing chord	83.3
Travel:	
Up, deg	0
Down, deg	40
Fence:	
Total area, sq ft	5.128
Location (from plane of symmetry), in.	75
Horizontal tail:	
Airfoil section (parallel to fuselage center line):	
Root	NACA 65A006
Tip	NACA 65A004
Area, sq ft	65.5
Span, ft	15.17
Sweep at 25 percent chord, deg	35
Aspect ratio	3.5
Taper ratio	0.4
Elevator (operative only when flaps are down):	
Area, sq ft	10.9
Hinge line, percent horizontal-tail chord	75
Travel, moves down only (measured from plane of horizontal tail), deg:	
When horizontal-tail deflection is 0°	1
When horizontal-tail deflection is -8°	6.5
When horizontal-tail deflection is -15°	19.3
When horizontal-tail deflection is -18°	30
Vertical tail:	
Total area (exposed), sq ft	45.1
Airfoil section:	
Root	NACA 16-005.625
Tip	NACA 16-005.625
Rudder:	
Area, sq ft	7.36

TABLE II.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADINGS POSSIBLE ON THE GRUMMAN F11F-1 AIRPLANE AND FOR LOADINGS TESTED ON THE 1/24-SCALE MODEL

[Model values given are converted to full-scale; moments of inertia are given about the center of gravity]

Loading		Weight, lb	Center-of-gravity location		Relative density, μ		Moments of inertia, slug-ft^2			Mass parameters		
			$x/\bar{c}$	$z/\bar{c}$	Sea level	Altitude, 25,000 ft	I_X	I_Y	I_Z	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z -}{mb^2}$
Airplane values												
Combat gross weight: Production nose	Clean condition	18,350	0.206	-------	30.22	67.70	5,800	41,000	44,500	-618×10^{-4}	-61×10^{-4}	679 ×
	2 empty 150-gal drop tanks	18,824	0.211	-------	31.12	69.48	7,200	43,000	48,200	-612	-89	701
	2 full 150-gal drop tanks	20,774	0.216	-------	34.31	76.60	12,600	43,600	53,700	-481	-156	637
Combat gross weight: Elongated APS-67 nose	Clean condition - forward center of gravity	18,619	0.250	-------	30.74	68.65	5,742	44,189	47,711	-665	-61	726
	Clean condition - rearward center of gravity	18,619	0.202	-------	30.74	68.65	5,742	44,189	47,711	-665	-61	726
	2 empty 150-gal drop tanks	19,093	0.250	-------	31.54	70.43	7,002	44,470	49,198	-632	-80	712
	2 full 150-gal drop tanks	21,043	0.250	-------	34.79	77.67	12,206	45,411	55,083	-508	-148	656
Model values												
Combat gross weight: Production nose	Clean condition	18,295	0.206	-0.063	30.21	67.46	6,010	41,166	44,227	-619×10^{-4}	-54×10^{-4}	673 ×
	2 full 150-gal drop tanks	20,723	0.209	-0.054	34.26	76.48	12,634	44,034	52,968	-488	-138	626
Combat gross weight: Elongated APS-67 nose	Clean condition	18,540	0.245	-0.072	30.64	68.41	6,114	45,108	48,120	-677	-52	729
	2 empty 150-gal drop tanks	19,113	0.254	-0.086	31.60	70.55	6,995	45,703	50,832	-652	-86	738
	2 full 150-gal drop tanks	21,105	0.258	-0.049	34.84	77.79	12,678	46,822	55,653	-521	-135	656

[redacted]

TABLE III.- SPIN-RECOVERY PARACHUTE DATA OBTAINED WITH 1/24-SCALE MODEL OF THE

GRUMMAN F11F-1 AIRPLANE WITH ELONGATED APS-67 NOSE CONFIGURATION

[Combat gross-weight loading with center of gravity at 25.0 percent of the mean aerodynamic chord; rudder fixed full with the spin and recovery attempted by opening the parachute only; model values converted to corresponding full-scale values]

Parachute diameter (laid out flat), ft	Drag coefficient	Towline length, ft	Flaperon deflection, deg	Horizontal-tail leading edge, deg	Wing tanks installed as indicated	Idle engine speed simulated as indicated	V, ft/sec	α, deg	Ω, rps	Tu re
Left erect spins										
11.0	0.634	32.0	Right 0 Left 0	5 up	No tanks	Opposite sense to spin direction	299	[a]56 77	0.21	$\frac{1}{4}$, 1,
12.0	.644	32.0	Right 0 Left 0	5 up	No tanks	Opposite sense to spin direction	299	[a]56 77	0.21	$\frac{1}{2}$, $\frac{1}{2}$
12.0	.644	32.0	Right 0 Left 0	5 up	Tanks empty	Engine speed not simulated	285	[a]70 85	0.22	
Inverted spins to pilot's left										
12.0	.644	32.0	Right 0 Left 55 up	5 up	Tanks empty	Engine speed not simulated	299	62	0.19	$\frac{3}{4}$
12.0	.644	32.0	Right 0 Left 55 up	5 up	No tanks	Engine speed not simulated	299	[a]61 73	0.20	$\frac{1}{2}$,
12.0	.644	32.0	Right 0 Left 55 up	5 up	Tanks full	Engine speed not simulated	320	62	0.18	$\frac{1}{2}$,

[a]Oscillatory spin, range of values given.

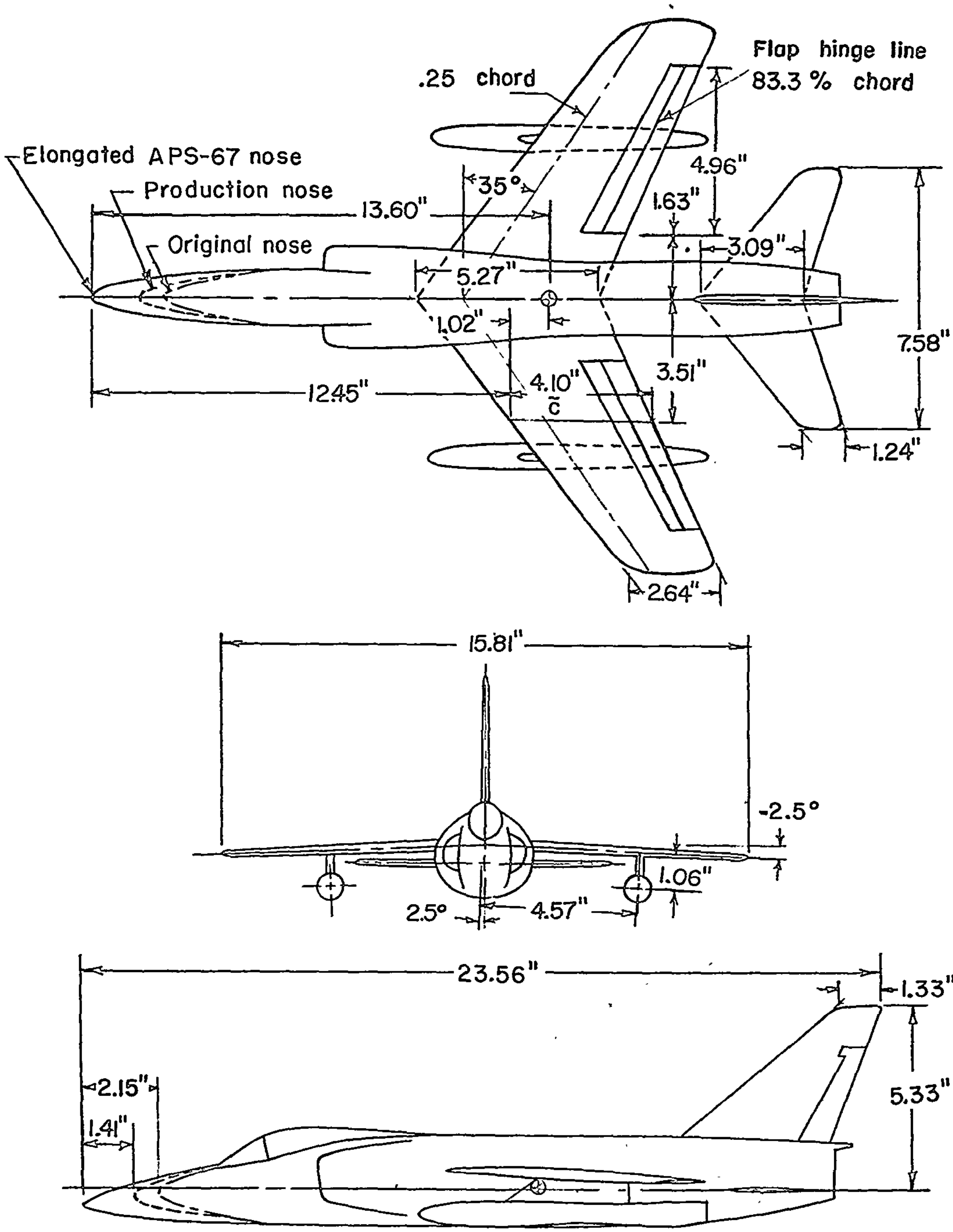


Figure 1.- Three-view drawing of the 1/24-scale model of the Grumman F11F-1 airplane as tested in the Langley 20-foot free-spinning tunnel. Center-of-gravity position shown is 25.0 percent mean aerodynamic chord. All dimensions are model scale.

[redacted]

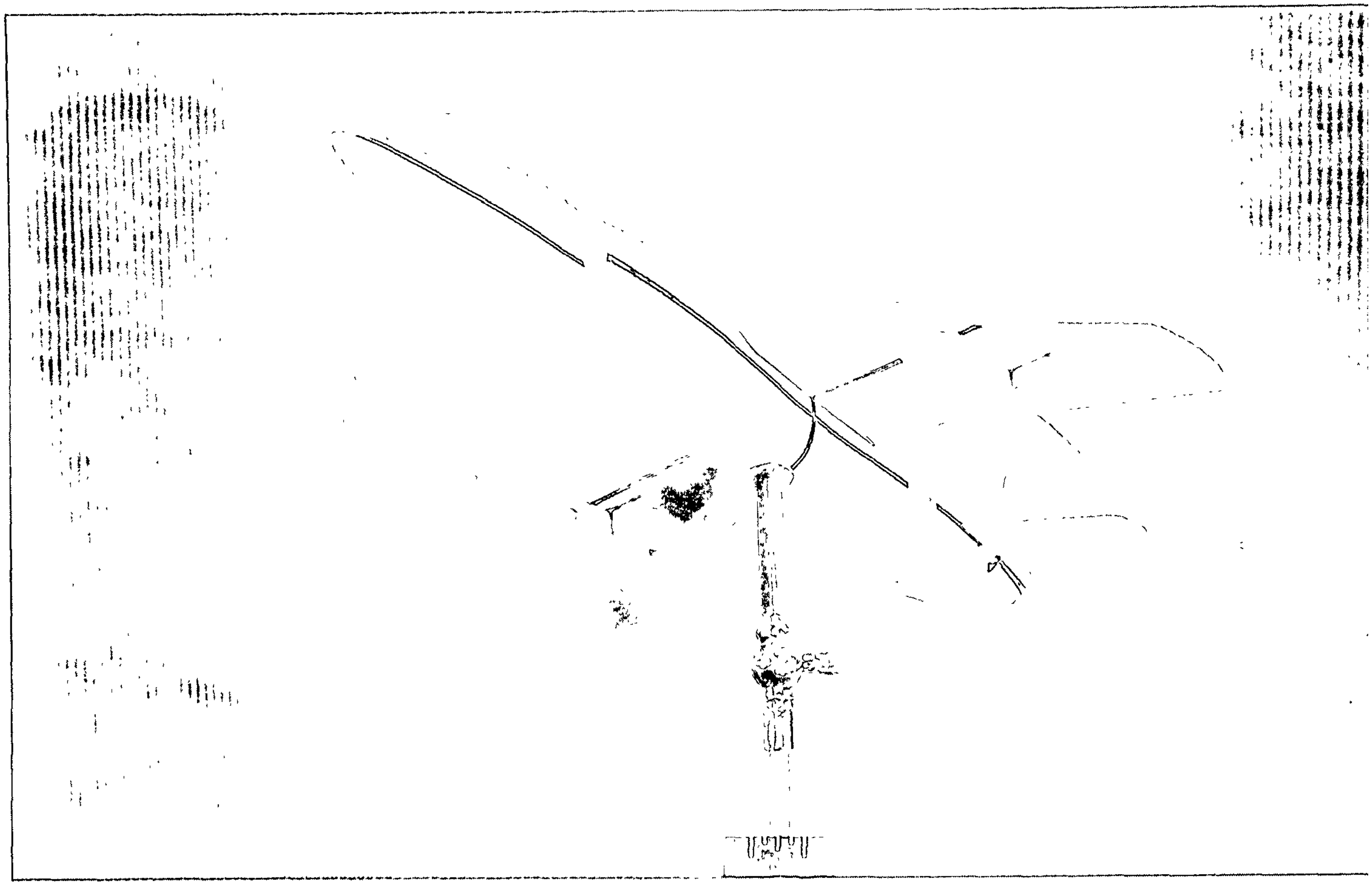


Figure 2.- Photograph of the 1/24-scale model of the Grumman F11F-1 airplane with wing fue
Production nose version shown.

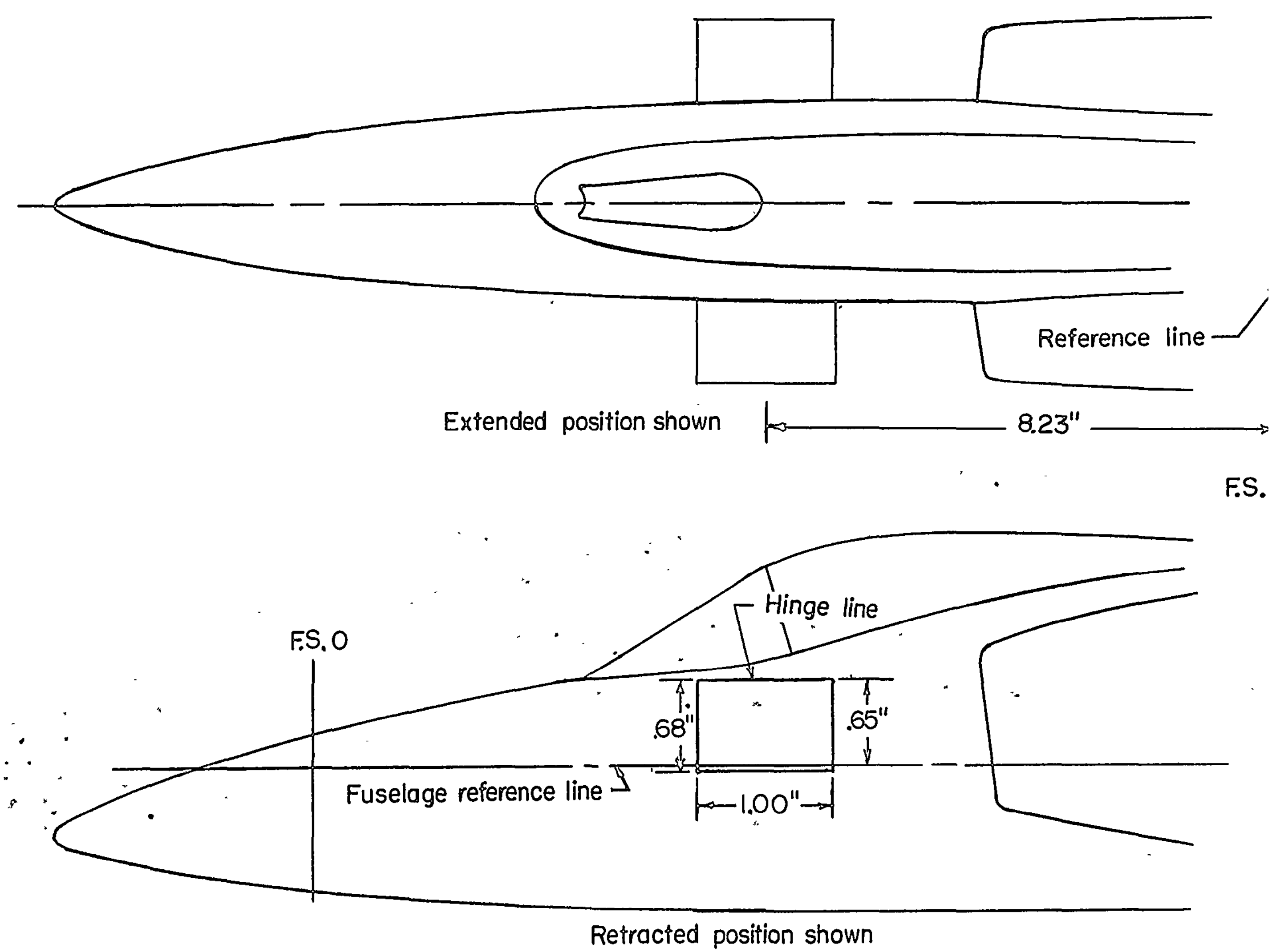


Figure 3.- Sketch showing position of canards tested on the 1/24-scale model of th
Grumman F11F-1 airplane. Dimensions are model values.

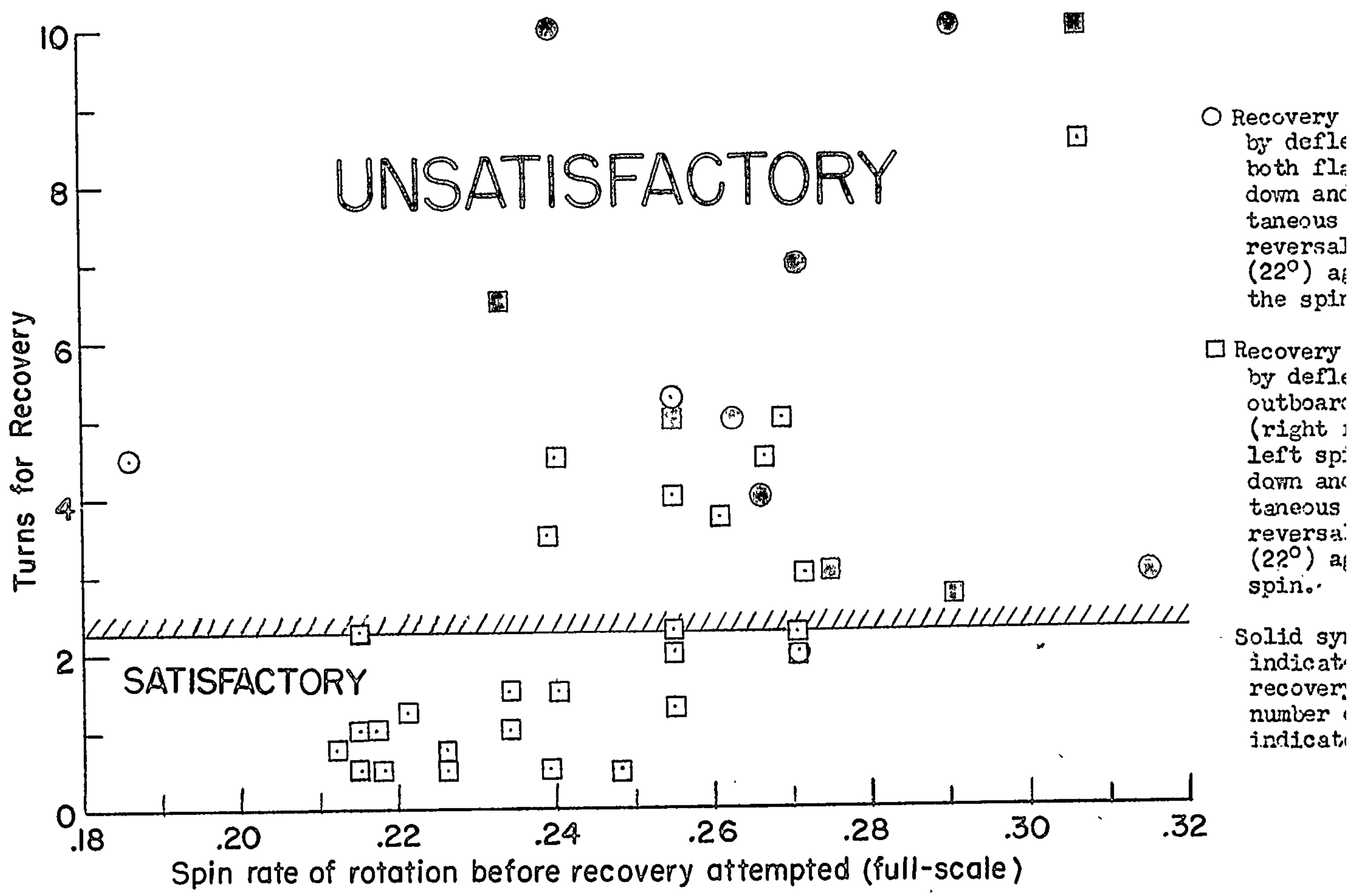


Figure 4.- Effect of wing trailing-edge flap deflection on the erect spin-recovery characteristics as determined on a 1/24-scale model of the Grumman F11F-1 airpla

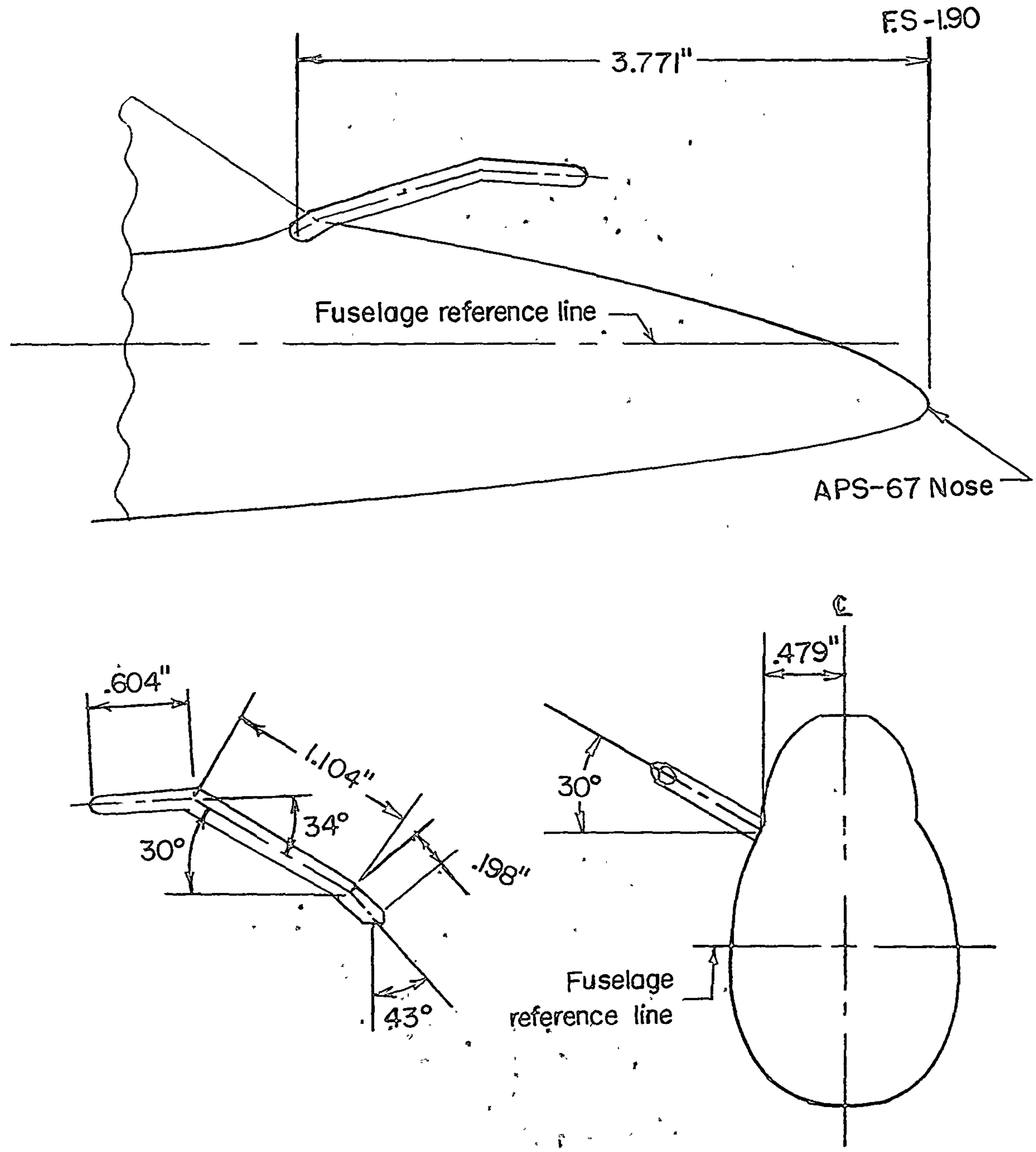


Figure 5.- Refueling probe as tested on the 1/24-scale model of the Grumman F11F-1 airplane. All dimensions are model scale.

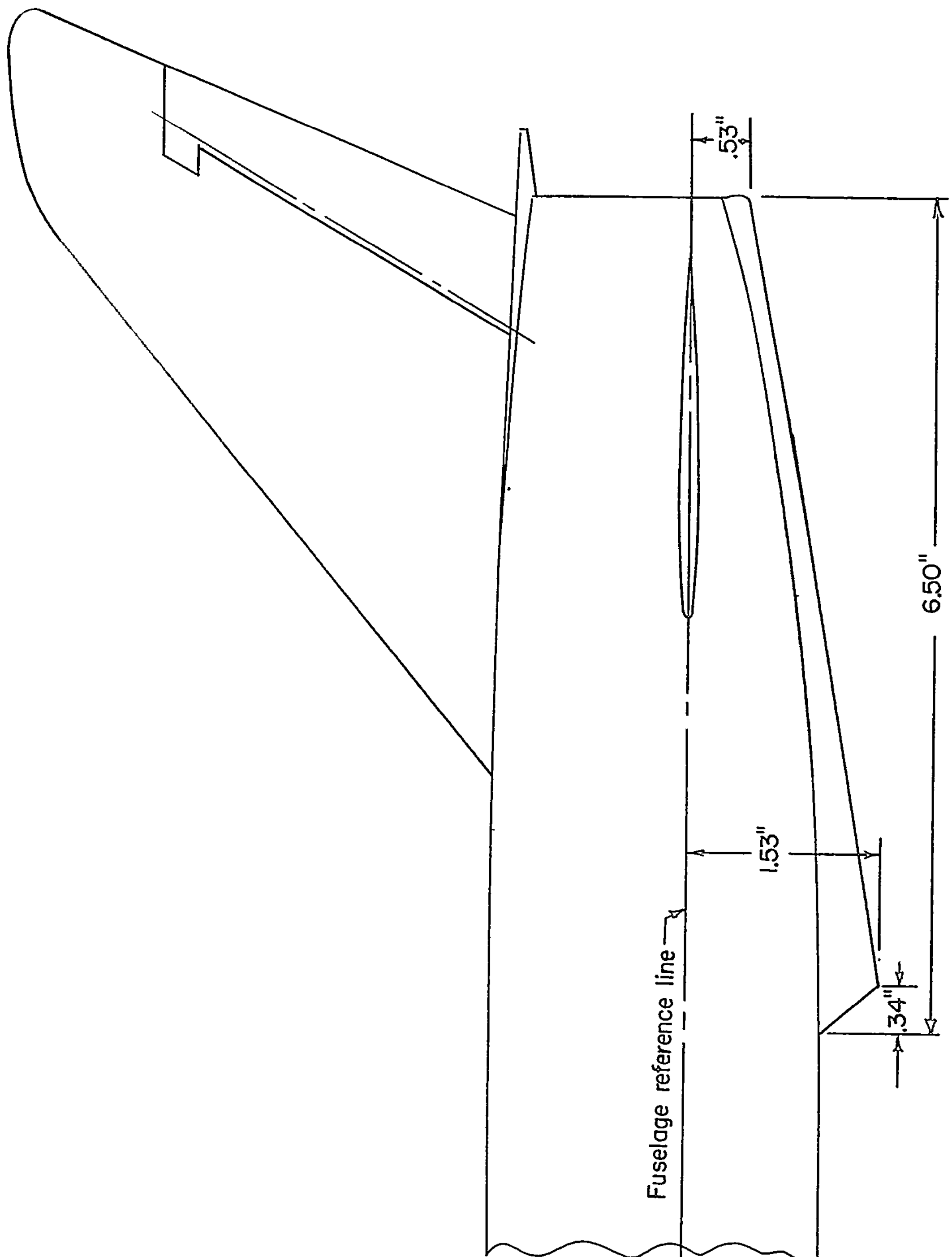


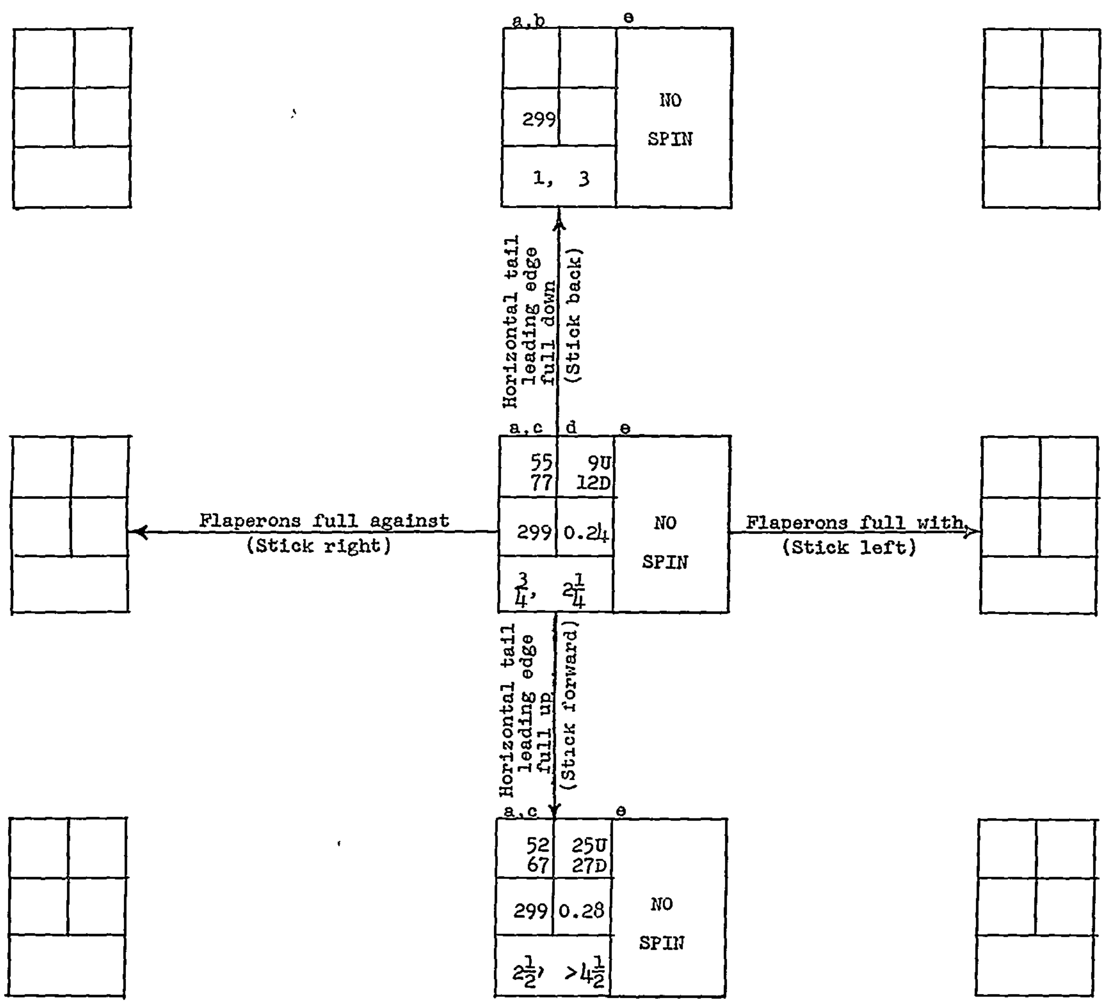
Figure 6.- Ventral fin as tested on the 1/24-scale model of the Grumman F11F-1 airplane. All dimensions are model scale.

CHART 1.–SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by rapid full rudder reversal (recovery attempted from, and developed-spin data presented for, rudder-full-with spins)]

Airplane	Attitude	Spin direction simulated	Loading (see table II) Combat Gross Weight (clean condition) Elongated APS-67 nose	Engine rotation
F11F-1	Erect			
Slats	Altitude		Desired center-of-gravity position	not simulated
Closed	25,000 ft	Left	25 percent $\bar{c}$	

Model values converted to full scale U-inner wing up D-inner wing down



[a]Two conditions possible.
[b]Oscillatory spin.
[c]Oscillatory spin, range of values given.
[d]The model sometimes spun for short duration only (8 to 12 turns) then entered a dive.
[e]Entered a dive.

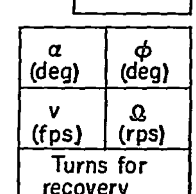
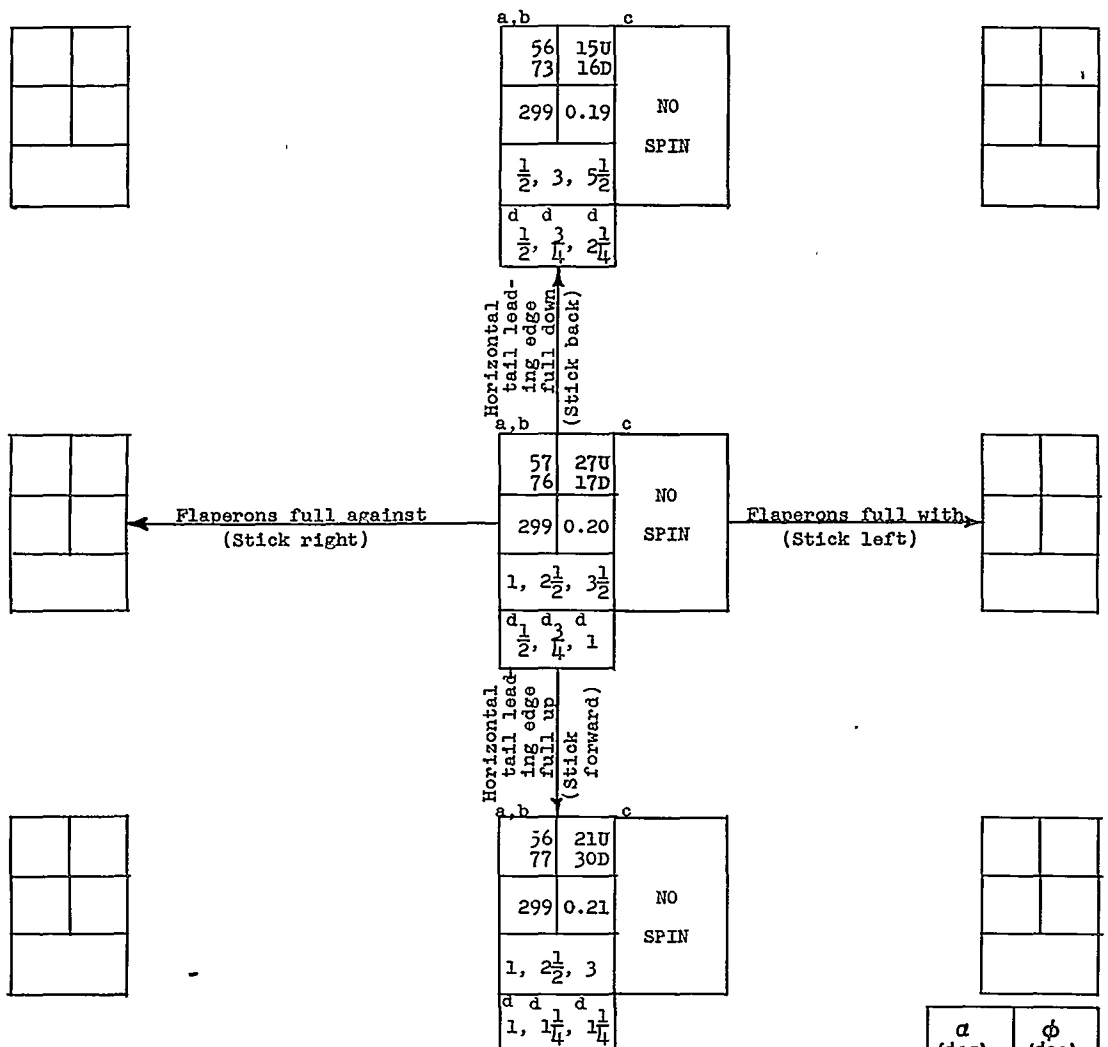


CHART 2.-SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by rapid full rudder reversal unless otherwise noted (recovery attempted from, and developed-spin data presented for, rudder-full-with spins)]

Airplane F11F-1	Attitude Erect	Spin direction simulated	Loading (see table II) Combat Gross Weight (clean condition) Elongated APS-67 nose	Idle engine speed simulated (engine rotation and spin direction in opposite sense)
Slats Closed	Altitude 25,000 ft	Left	Desired center-of-gravity position 25 percent $\bar{c}$	

Model values converted to full scale U-inner wing up D-inner wing down



α (deg)	φ (deg)
V (fps)	Ω (rps)
Turns for recovery	

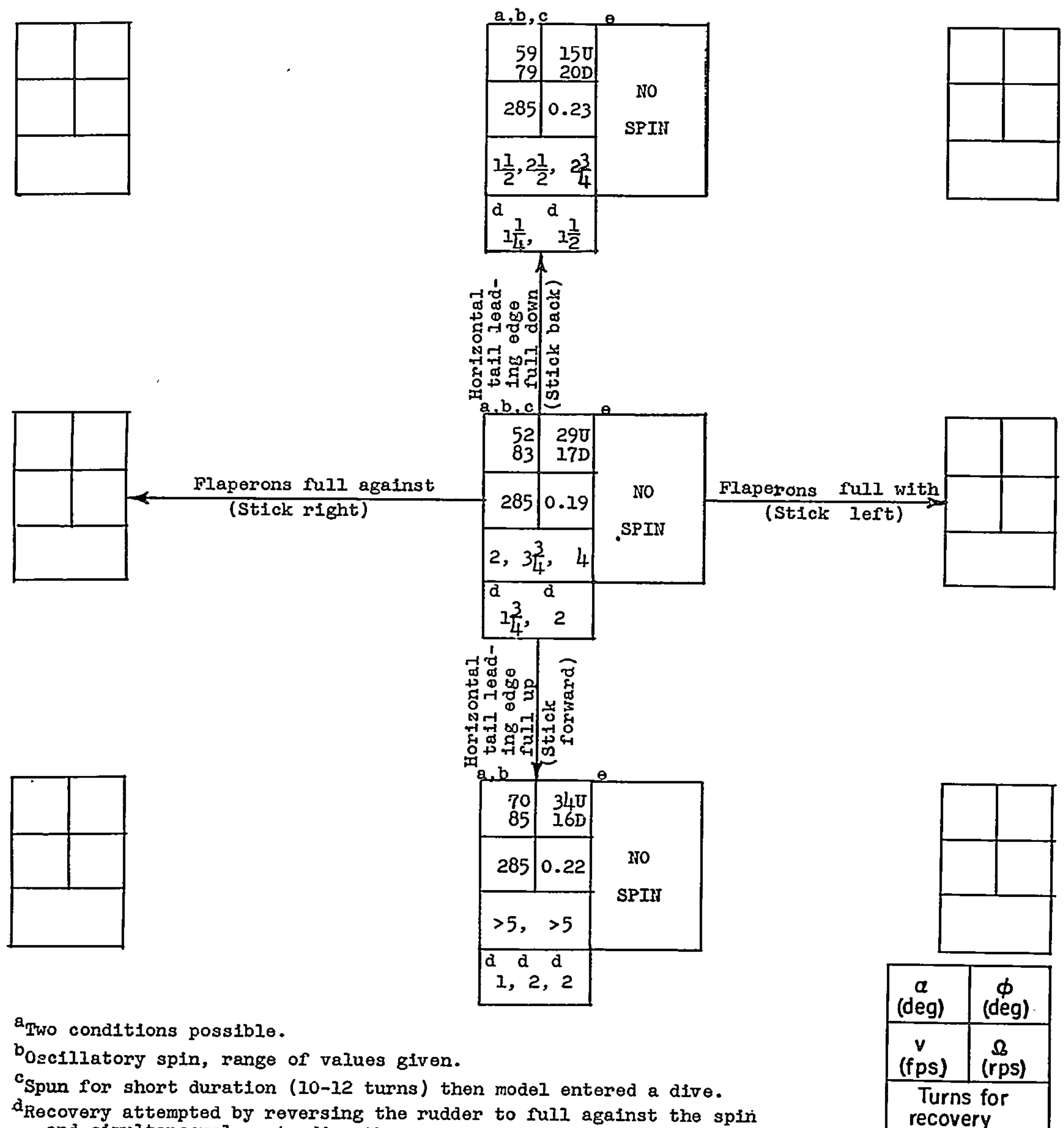
[a] Two conditions possible.
[b] Oscillatory spin, range of values given.
[c] Model entered a dive.
[d] Recovery attempted by reversing the rudder to full against the spin and simultaneously extending the canard surfaces.

CHART 3.–SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by rapid full rudder reversal unless otherwise noted (recovery attempted from, and developed-spin data presented for, rudder-full-with spins)]

Airplane F11F-1	Attitude Erect	Spin direction simulated Left	Loading (see table II) Combat Gross Weight (empty wing tanks) Elongated APS-67 nose.	Engine rotation not simulated.
Slats Closed	Altitude 25,000 ft		Desired center-of-gravity position 25 percent $\bar{c}$	

Model values converted to full scale U-inner wing up D-inner wing down



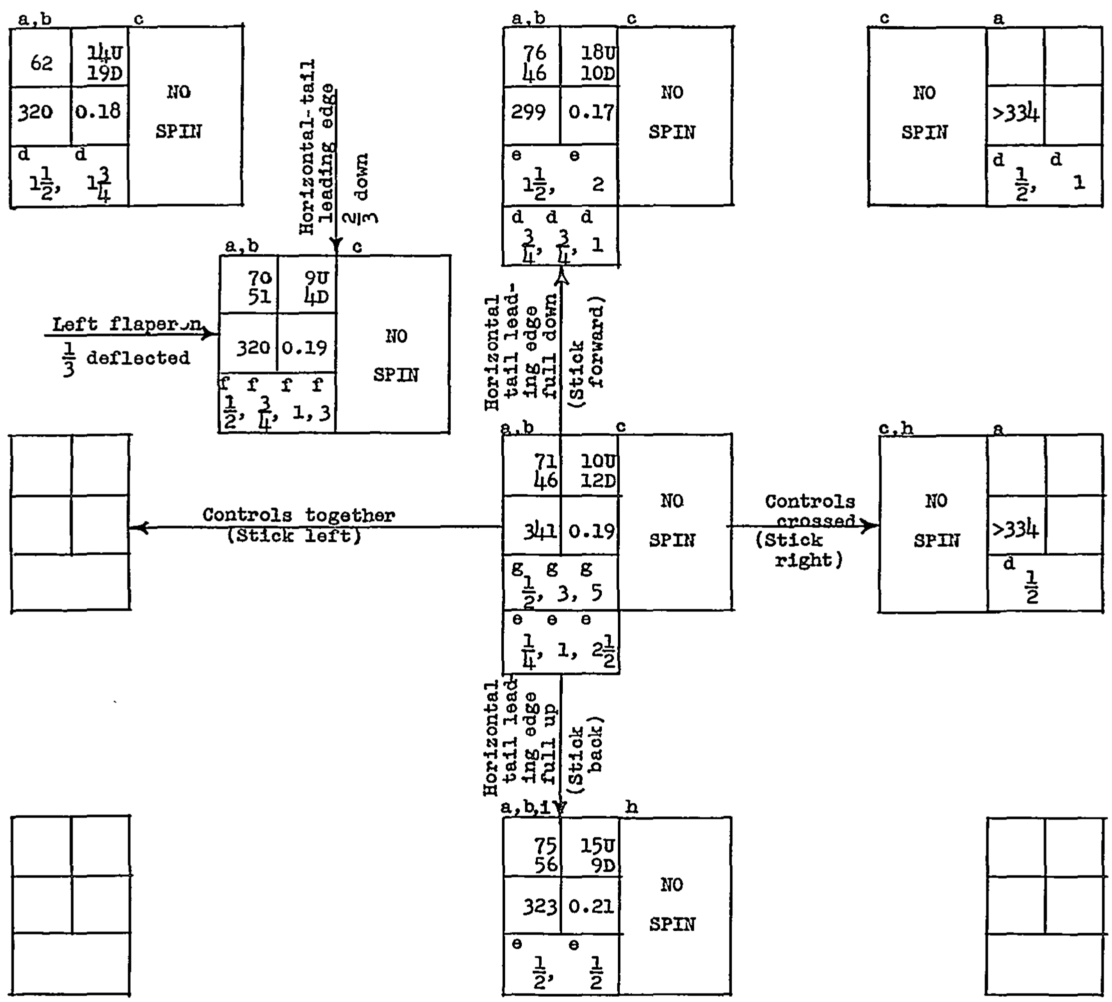
[a]Two conditions possible.
[b]Oscillatory spin, range of values given.
[c]Spun for short duration (10-12 turns) then model entered a dive.
[d]Recovery attempted by reversing the rudder to full against the spin and simultaneously extending the canard surfaces.
[e]Entered a glide or dive.

CHART 4 .–SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Recovery attempted by rapid full rudder reversal as indicated (recovery attempted from, and developed-spin data presented for, rudder-full-with spins)]

Airplane F11F-1	Attitude Inverted	Spin direction simulated	Loading (see table II) Combat gross weight (full wing tanks) Elongated APS-67 nose	Engine rotation not simulated
Slats Closed	Altitude 25,000 ft	To pilot's left	Desired center-of-gravity position 25 percent $\bar{c}$	

Model values converted to full scale U-inner wing up D-inner wing down



[a]Two conditions possible.
[b]Oscillatory spin, range or average values given.
[c]Entered a dive.
[d]Recovery attempted by reversing the rudder to 22° against the spin.
[e]Recovery attempted by reversing the rudder to 10° against the spin.
[f]Recovery attempted by reversing the rudder to 2/3 of 22° against the spin.
[g]Recovery attempted by reversing the rudder to 5° against the spin.
[h]Model entered a vertical roll about X-axis.
[i]Model oscillated out of spin after about 10 to 12 turns in the developed spin.

α (deg)	ϕ (deg)
V (fps)	Ω (rps)
Turns for recovery	

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TED NO. NACA AD 395

By James S. Bowman, Jr.

ABSTRACT

The spin and recovery characteristics of the model with either alternate nose were generally similar to those obtained for the original nose configuration (NACA Research Memorandums SL55G20 and SL56H02). The addition of empty wing tanks had little effect on the developed erect spin and recovery characteristics. The model did not spin erect with full wing tanks.

INDEX HEADINGS

Stores - Airplane Components	1.7.1.1.5
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AN INVESTIGATION OF THE FREE-SPINNING AND RECOVERY CHARACTERISTICS OF A 1/24-SCALE MODEL OF THE GRUMMAN F11F-1 AIRPLANE WITH ALTERNATE NOSE CONFIGURATIONS WITH AND WITHOUT WING FUEL TANKS

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